(12) UK Patent Application (19) GB (11) 2 300 545 (13) A

(43) Date of A Publication 06.11.1996

(21) Application No 9508974.4

(22) Date of Filing 03.05.1995

(51) INT CL^6
H04L 27/20 , H04B 7/216

(52) UK CL (Edition O)
H4P PAQ

(56) Documents Cited
GB 2283627 A GB 2282289 A

(58) Field of Search
UK CL (Edition N) H4P PAQ
INT CL^6 H04B 7/216 , H04L 27/18 27/20

(71) Applicant(s)
Motorola Limited

(Incorporated in the United Kingdom)

European Intellectual Property Operation, Jays Close, Viables Industrial Estate, BASINGSTOKE, Hampshire, RG22 4PD, United Kingdom

(72) Inventor(s)
Nicholas William Whinnett
William Neil Robinson
Jonathan Alastair Gibbs

(74) Agent and/or Address for Service
Hugh Dunlop
Motorola Limited, European Intellectual Property Operation, Midpoint, Alencon Link, BASINGSTOKE, Hampshire, RG21 7PL, United Kingdom

(54) **Processing binary phase-shift keyed signals**

(57) A method for processing binary phase-shift keyed signals in a communications system comprises the steps of; at the transmitting unit 48, scaling 53, 55 the binary phase-shift keyed signals according to the desired power and/or bit rate and adding 58 the scaled binary phase-shift keyed signals in quadrature to form a quadrature imbalanced multiplexed signal 65. Multiplying the quadrature imbalanced multiplexed signal 65 by a phase-shifting signal 69 to provide a transmitted signal. At the receiving unit (71, Fig 4); receiving the first transmitted signal and multiplying the first transmitted signal by a second phase-shifting signal (81) to recover the original binary phase-shift keyed signals.

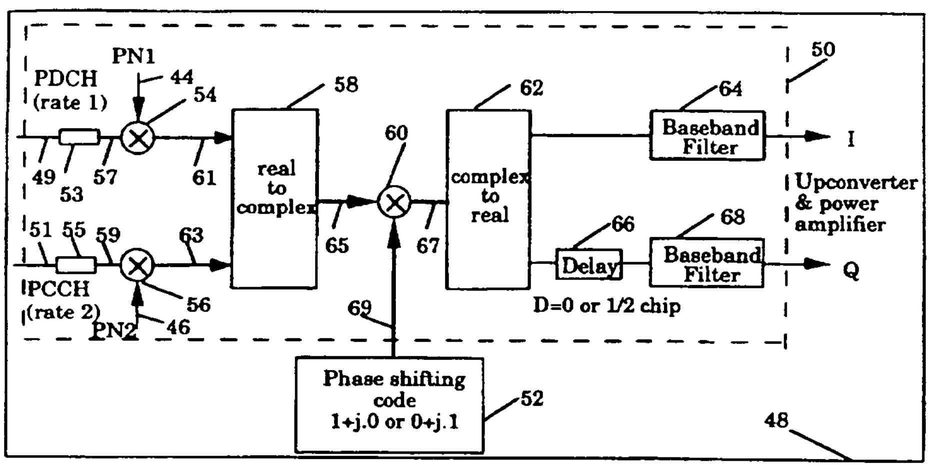


FIG. 3

GB 2 300 545 A

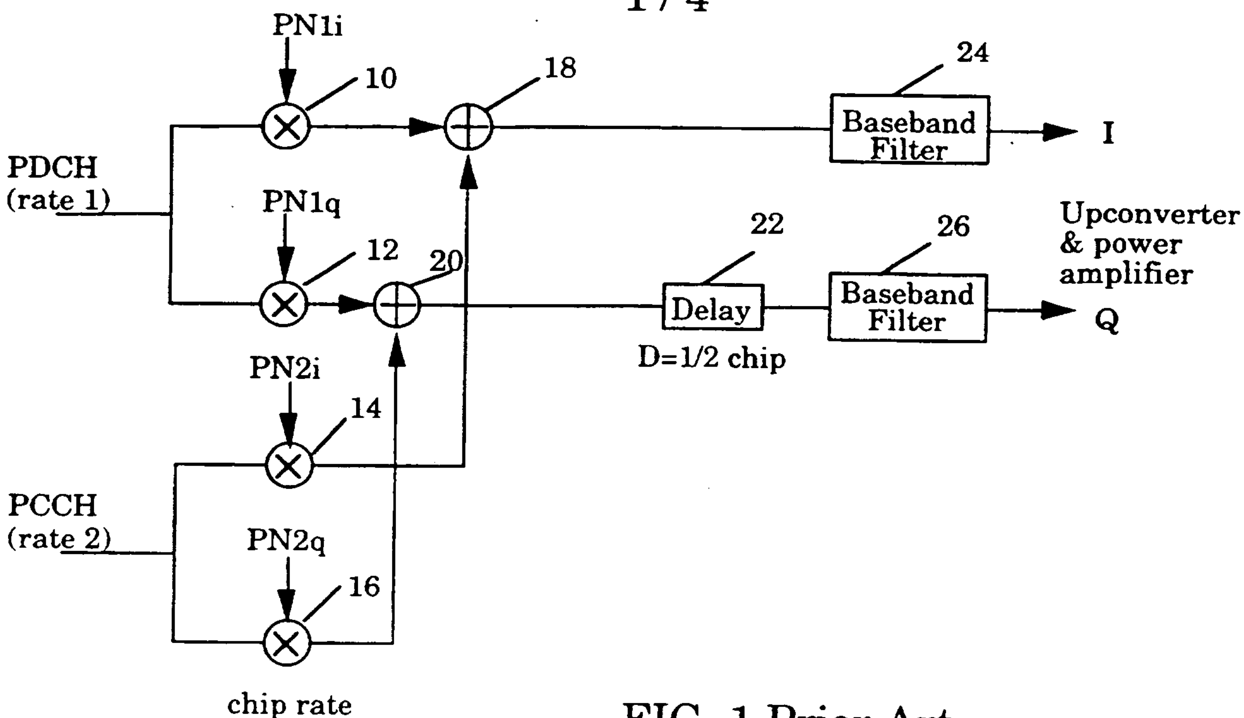


FIG. 1 Prior Art

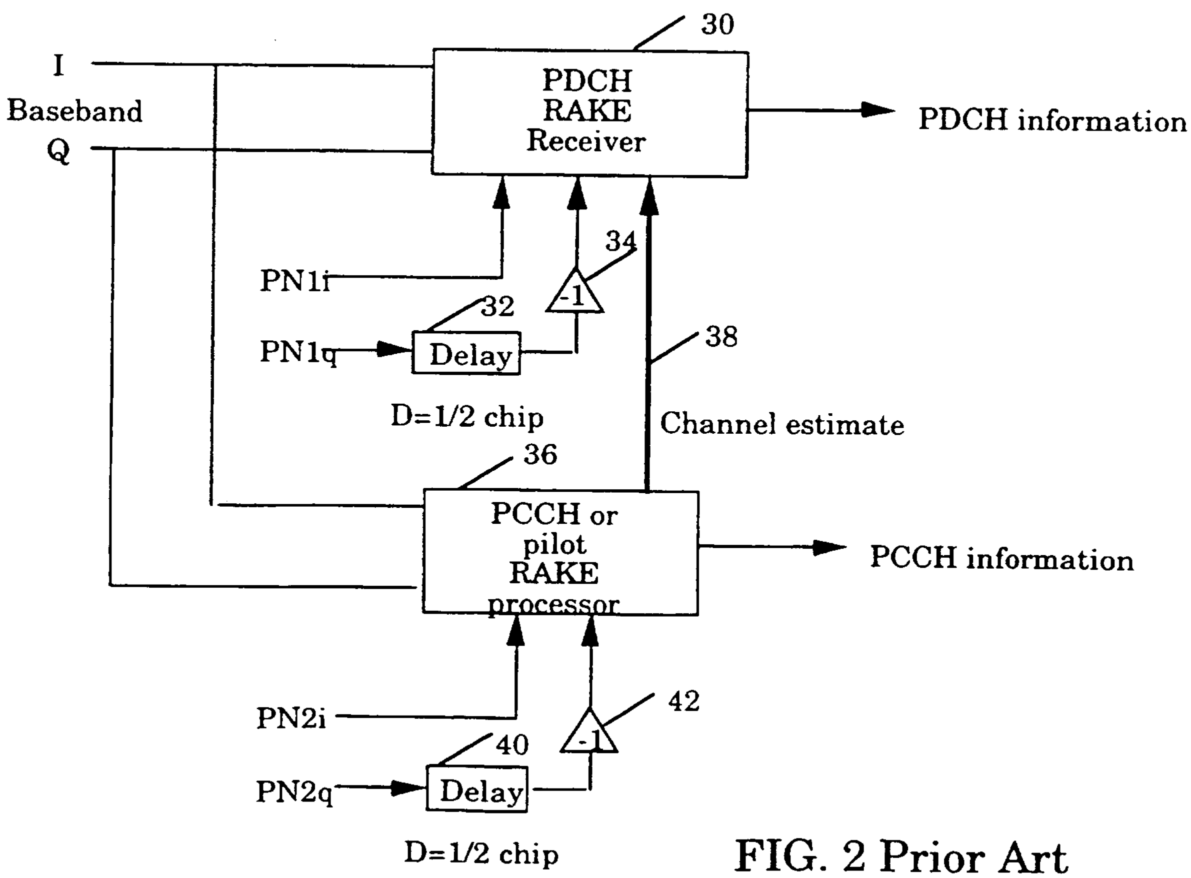


FIG. 2 Prior Art

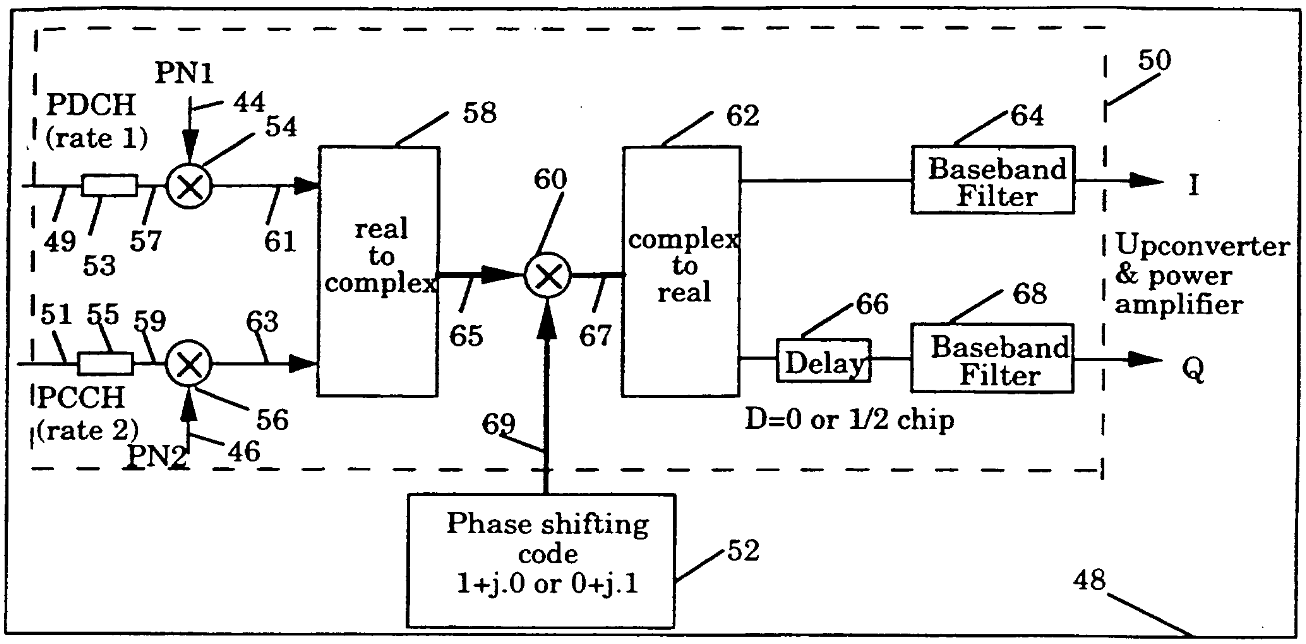

PDCH
(rate 1)
PN1
44
54
49
53
57
61
51
55
59
63
PCCH
(rate 2)
PN2
46
56
58
real
to
complex
65
60
67
69
62
complex
to
real
64
Baseband
Filter
66
Delay
68
Baseband
Filter
D=0 or 1/2 chip
I
Q
50
Upconverter
& power
amplifier
Phase shifting
code
1+j.0 or 0+j.1
52
48

FIG. 3

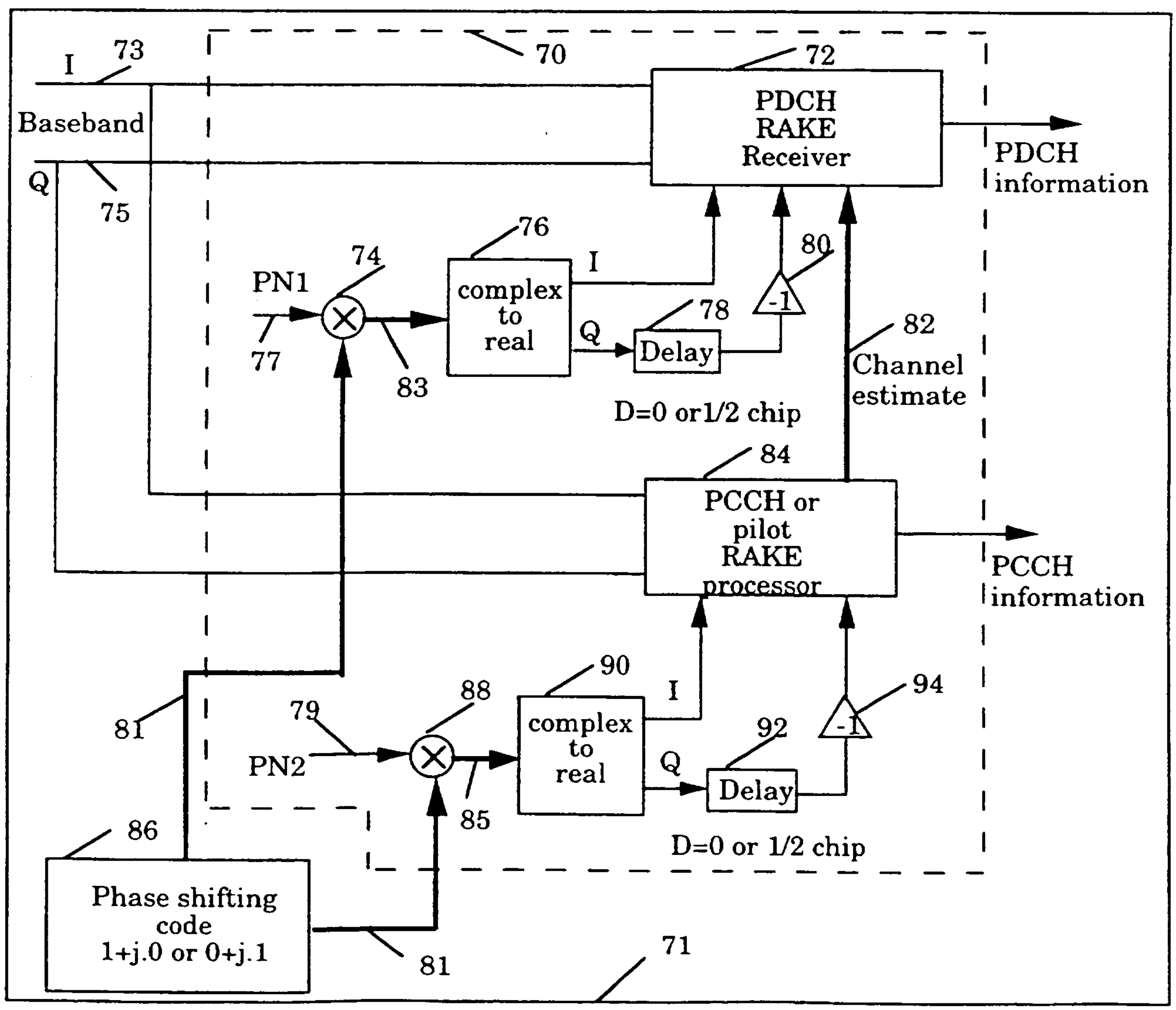

I
73
Baseband
Q
75
70
72
PDCH
RAKE
Receiver
PDCH
information
PN1
74
77
83
76
complex
to
real
I
Q
78
Delay
80
-1
D=0 or1/2 chip
82
Channel
estimate
84
PCCH or
pilot
RAKE
processor
PCCH
information
81
79
PN2
88
85
90
complex
to
real
I
Q
92
Delay
94
-1
D=0 or 1/2 chip
86
Phase shifting
code
1+j.0 or 0+j.1
81
71

FIG. 4

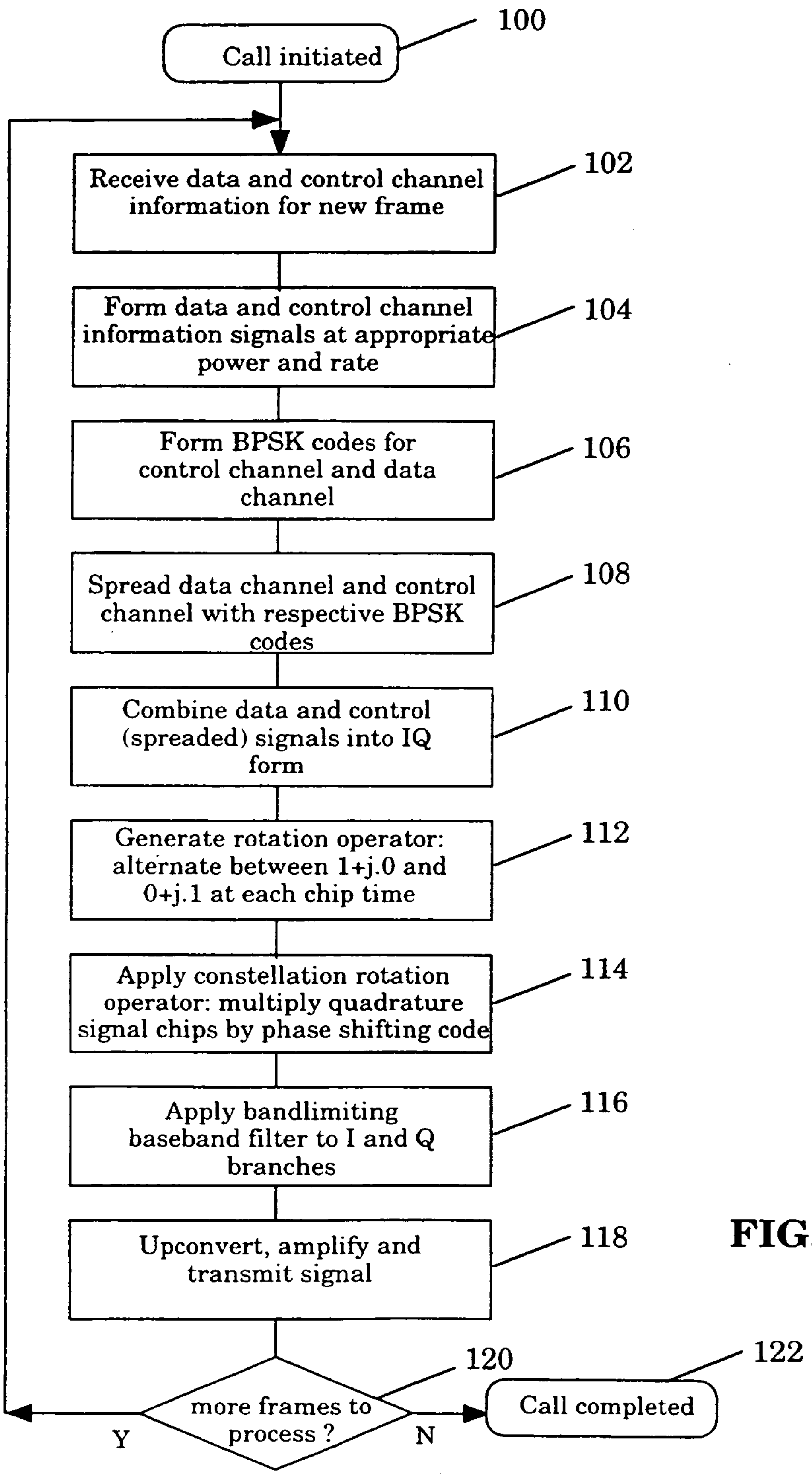

Call initiated
100
Receive data and control channel information for new frame
102
Form data and control channel information signals at appropriate power and rate
104
Form BPSK codes for control channel and data channel
106
Spread data channel and control channel with respective BPSK codes
108
Combine data and control (spreaded) signals into IQ form
110
Generate rotation operator: alternate between 1+j.0 and 0+j.1 at each chip time
112
Apply constellation rotation operator: multiply quadrature signal chips by phase shifting code
114
Apply bandlimiting baseband filter to I and Q branches
116
Upconvert, amplify and transmit signal
118
more frames to process ?
120
Y
N
Call completed
122

FIG. 5

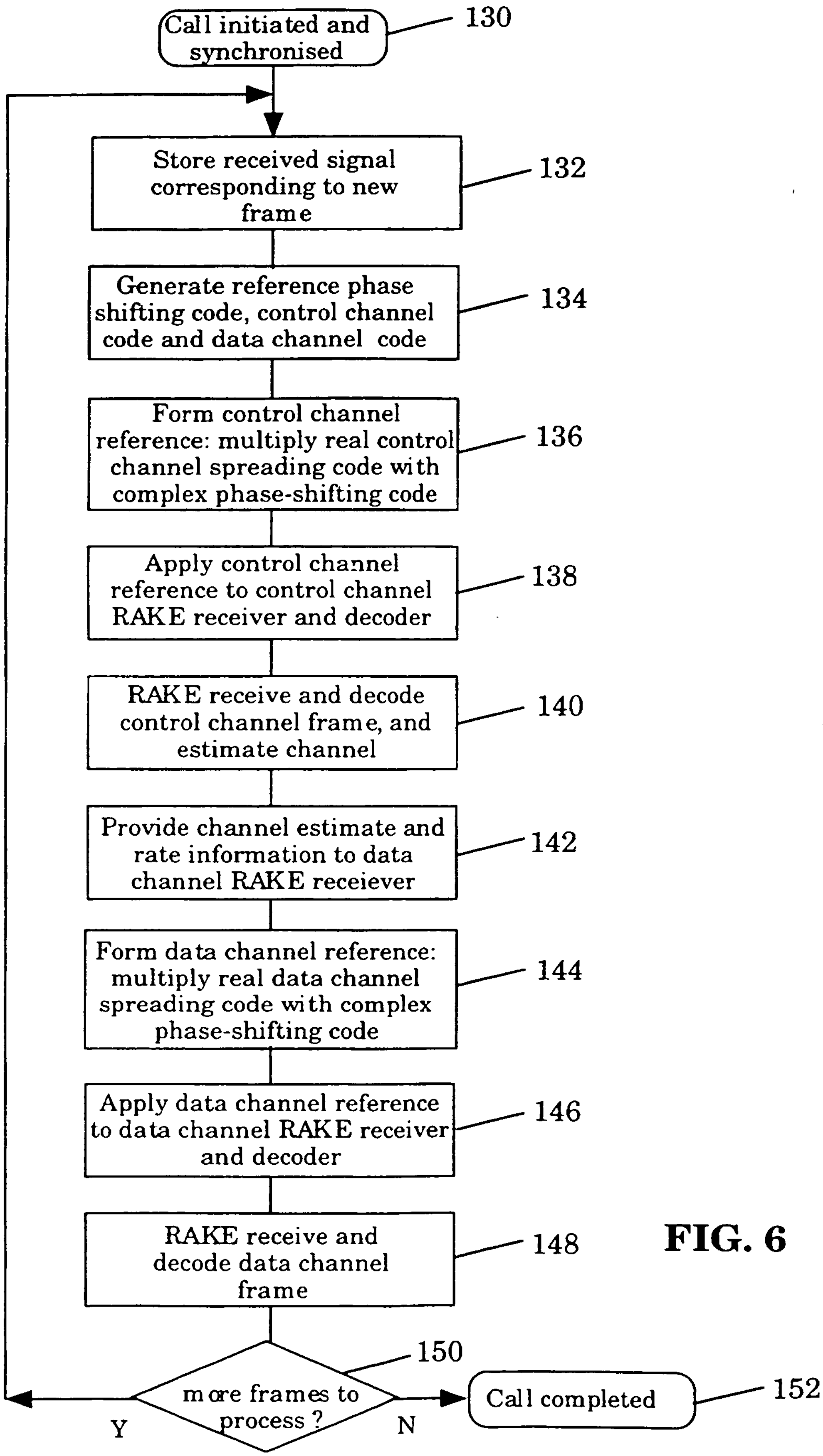

Call initiated and synchronised
130
Store received signal corresponding to new frame
132
Generate reference phase shifting code, control channel code and data channel code
134
Form control channel reference: multiply real control channel spreading code with complex phase-shifting code
136
Apply control channel reference to control channel RAKE receiver and decoder
138
RAKE receive and decode control channel frame, and estimate channel
140
Provide channel estimate and rate information to data channel RAKE receiever
142
Form data channel reference: multiply real data channel spreading code with complex phase-shifting code
144
Apply data channel reference to data channel RAKE receiver and decoder
146
RAKE receive and decode data channel frame
148
150
more frames to process ?
Y
N
Call completed
152

FIG. 6

A METHOD FOR PROCESSING SIGNALS

Field of the Invention

This invention relates to signal processing and more particularly, to a method of processing signals in communications devices.

Background of the Invention

For the future provision of mobile communications services, it is envisaged that a number of communications systems will use code division multiple access (CDMA) schemes such as the U.S. IS95 Cellular System developed by Qualcomm. In Europe, research into future third generation communications systems, using CDMA technology, is being carried out by the RACE CODIT research project. The RACE CODIT research project is described in a paper by Per-Goran Andermo and Lars-Magnus Ewerbring titled "A CDMA-based radio access design for UMTS", IEEE Personal Communications, Feb. 1995

The uplink modulation scheme chosen for the Qualcomm and RACE CODIT communications systems is offset quadrature phase-shift keying (OQPSK), due to its low peak-to-average ratio when compared to alternative digital modulation schemes such as quadrature amplitude modulation (QAM). Employing a digital modulation scheme that has a low peak-to-average ratio reduces the cost and size as well as improves the operating efficiency of the transmitter's power amplifier.

In the RACE CODIT research project, it is proposed that two OQPSK signals are code division multiplexed onto uplink channels, e.g. communication channels between a mobile station (MS) and a base station (BS). Superimposing two OQPSK signals in this way detrimentally increases the overall peak to average ratio of the uplink transmission. Qualcomm and the RACE CODIT project both employ quadrature spreading techniques, for the CDMA transmissions, wherein a binary information signal is applied to both the I and Q branches of the modulator and are spread by different binary codes, thereby producing the CDMA OQPSK modulation. A prior art design of the quadrature spreading technique, is shown in FIG. 1. FIG. 1 also shows the process of combining the two OQPSK signals. In the RACE CODIT project, a first binary information signal (the physical control channel or PCCH) acts as a pilot

reference for recovering the second binary information signal (the physical data channel or PDCH) containing the signalling and/or data.

For a CDMA downlink channel, e.g. a communication channel from a BS to a MS, quadrature spreading is desirable. After de-spreading in the mobile receiver, half of the interference falls in quadrature to the desired signal and therefore only half of the interference power degrades the desired signal.

However, for a CDMA uplink channel, it is not necessary to use quadrature spreading techniques as signals from different mobile stations arrive at the CDMA base station with random phase. Hence, if binary phase-shift keyed (BPSK) spreading is employed on the uplink channel, when compared to quadrature phase-shift keyed spreading, the complexity of the spreading and de-spreading operations is reduced. This fact is noted in the paper entitled "CDMA Modulation with real sequences - How to simplify transceivers without losing capacity", by P. Lucas et. al., proceedings of the RACE workshop, May 1994.

When two BPSK signals of equal power are combined, with a half chip period time differential as shown in the prior art of FIG. 1, the transmitted signal resembles an offset quadrature phase-shift keyed (QPSK) signal. The peak-to-average ratio of the combined BPSK signals, when compared to the combined OQPSK signals, is significantly reduced. A disadvantage of using BPSK transmissions for the uplink channel occurs when the two BPSK signals have a large power differential at the combining stage. This causes the signal constellation to become asymmetric and may increase the peak to average ratio of the transmitted signal.

Thus it is desirable to have a method for processing and combining two BPSK signals to minimise the combined peak-to-average ratio of the resultant signal.

Summary of the Invention

According to the invention, a method is provided for processing first and second binary phase-shift keyed signals in a communications system having a transmitting unit and a receiving unit. At the transmitting unit, the method comprises the steps of scaling the first and second binary phase-shift keyed signals according to the desired power and/or bit rate of the first and second binary phase-shift keyed signals, to provide scaled first and second binary phase-shift keyed signals. The scaled first binary phase-shift keyed signal is added to the scaled second binary phase-shift keyed signal in

quadrature to form a quadrature imbalanced multiplexed signal. The quadrature imbalanced multiplexed signal is multiplied by a first phase-shifting signal to provide a first transmitted signal.

At the receiving unit, the method comprises the steps of receiving the first transmitted signal and multiplying the received first transmitted signal by a second phase-shifting signal to recover the first and second binary phase-shift keyed signals.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the drawings.

Brief Description of the Drawings

FIG. 1 shows a prior art design of a transmitting unit for generating a CDMA multiplexed uplink channel.

FIG. 2 shows a prior art design of a receiving unit for receiving and recovering a CDMA multiplexed uplink channel.

FIG. 3 shows an uplink design of a transmitting unit, in accordance with a preferred embodiment of the invention.

FIG. 4 shows an uplink design of a receiving unit, in accordance with a preferred embodiment of the invention.

FIG. 5 is a flowchart detailing the signal processing of uplink control and data information at the transmitting unit, in accordance with a preferred embodiment of the invention.

FIG. 6 is a flowchart detailing the signal processing of uplink control and data information at the receiving unit, in accordance with a preferred embodiment of the invention.

Detailed Description of the Drawings

Referring first to FIG. 1, the prior art design of a transmitting unit generating a CDMA multiplexed uplink channel is shown. Two offset quadrature phase-shift keyed (OQPSK) information signals (i.e. in the RACE CODIT research project, a physical data channel (PDCH) and a physical control channel (PCCH)) are each applied to two baseband mixing units 10 and 12. The PDCH OQPSK signal is input to the baseband mixing units 10 and 12 where the PDCH OQPSK signal is multiplied to the in-phase 'I' and quadrature 'Q' components (PN1i and PN1q) of a first binary spreading code. The PCCH OQPSK signal is input to the baseband mixing units 14 and 16 where the PCCH OQPSK signal is multiplied to the in-

phase 'I' and quadrature 'Q' components (PN2i and PN2q) of a second binary spreading code. The multiplied in-phase PDCH and PCCH signals are added together by a summing function 18. The multiplied quadrature PDCH and PCCH signals are added together by a summing function 20. One of the resultant 'I' or 'Q' output signals, i.e. the quadrature signal in FIG. 1, is input into a delay function 22 and delayed by half a chip period to generate an offset quadrature phase-shift keyed OQPSK transmitted signal on finally up-converting, combining the 'I' and 'Q' signals and amplifying the signal for transmission. If a quadrature phase-shift keyed (QPSK) modulation scheme is used, and not an OQPSK scheme, the delay function is not required. The in-phase and quadrature output signals are input to baseband filters 24 and 26 respectively. The filtered output signals are input to the remainder of the transmitting unit for up-conversion, final combination and power amplification purposes.

In this manner two QPSK information signals are spread by independent binary spreading codes and later combined to generate an OQPSK code division multiplexed transmitted signal.

Referring now to FIG. 2, the prior art design of a receiving unit for receiving and recovering a CDMA multiplexed uplink channel is shown. Two RAKE receivers 30 and 36 are provided for recovering the received CDMA signals, as known to those skilled in the art.

In operation the first RAKE receiver 30 receives the recovered in-phase 'I' and quadrature 'Q' signals together with in-phase (PN1i) and quadrature (PN1q) components of the first binary spreading code. The components of the binary spreading codes for a particular communications channel are known to the receiving units of the communications system. The quadrature component of the first binary spreading code is input to a delay function 32 and delayed by a half-chip period followed by an inverting function 34. The inverting function is required to form the correct code for de-spreading, which, using complex notation, is the complex conjugate of the binary spreading code. If QPSK and not OQPSK is the chosen modulation scheme the delay function 32 is not required.

The second RAKE receiver 36 also receives the recovered in-phase 'I' and quadrature 'Q' signals together with in-phase (PN2i) and quadrature (PN2q) components of the second binary spreading code. The quadrature component of the second binary spreading code is input to a delay function 40 and delayed by a half-chip period followed by an inverting function 42 to form the correct code for de-spreading. The second RAKE receiver 36 recovers the PCCH information signal from the 'I' and 'Q' input signals and

provides a synchronisation and channel estimate signal 38 as well as a PDCH bit rate indication to the first RAKE receiver to enable recovery of the PDCH information signal from the 'I' and 'Q' input signals.

The communications device of the communications system, in accordance with the preferred embodiment of the invention, may include a transmitting unit 48 and/or a receiving unit 71.

Referring now to FIG. 3, an uplink design of the transmitting unit 48, in accordance with a preferred embodiment of the invention, is shown. Two binary phase-shift keyed (BPSK) information signals 49 and 51 (a physical data channel (PDCH) and a physical control channel (PCCH) in the RACE CODIT research project) are each input to a processing device 50 e.g. a microprocessor. The processing device 50 also receives a phase-shifting code signal from a rotational generation means. The rotational generation means is preferably a phase-shifting rotational operator 52. The processing device 50 comprises three baseband mixing units 54, 56 and 60, two scaling functions 53 and 55, a real-to-complex function 58, a complex-to-real function 62, a delay function 66 and two baseband filters 64 and 68.

In operation, the two binary phase-shift keyed (BPSK) information signals 49 and 51 are input to the two scaling functions 53 and 55. The two BPSK signals are scaled according to the desired power and/or bit rate for the BPSK signals. The scaled BPSK signals 57 and 59 are input to the two baseband mixing units 54 and 56 of the processing device 50. The scaled PDCH BPSK signal 57 is input to the baseband mixing unit 54 where the scaled PDCH BPSK signal 57 is multiplied by a first binary spreading code 44 (PN1). The scaled PCCH BPSK signal 59 is input to a second baseband mixing unit 56 where the scaled PCCH BPSK signal 59 is multiplied by a second binary spreading code 46 (PN2). The binary-spread scaled PDCH and PCCH BPSK signals 61 and 63 are input to a real-to-complex function 58 where they are converted to a complex form. The complex output signal is a quadrature imbalanced multiplexed signal 65, and is input to a rotational operational means, which is preferably a third baseband mixing unit 60. The quadrature imbalanced multiplexed signal 65 is multiplied by a phase-shifting code 69, e.g. in complex notation "1+j0" or "0+j1", generated by a phase-shifting rotational operator 52. The phase-shifted quadrature imbalanced multiplexed signal 67 is input to a complex-to-real function 62 to provide real 'I' and 'Q' output signals. One of the output signals of the complex-to-real function 62, i.e. the quadrature signal in FIG. 3, is input into a delay function 66 and delayed by half a chip period to generate a pseudo offset quadrature phase-shift keyed OQPSK transmitted signal. The

delay function is not required if pseudo QPSK signals are required. The in-phase and quadrature output signals are input to baseband filters 64 and 68 respectively. The filtered outputs (first transmitted signal) are transmitted, in an I/Q form, to the remainder of the transmitting unit for up-conversion, final combination and power amplification purposes.

In this manner two binary phase-shift keyed (BPSK) information signals 49 and 51 are spread by independent binary spreading codes 44 and 46 and partially combined to generate a pseudo OQPSK code division multiplexed transmitted signal. The transmitted signal is shown in 'I' and 'Q' form. The inclusion of a phase-shifting operation, by the phase-shifting rotational operator 52, advantageously rotates the quadrature imbalanced multiplexed signal 65, in its constellation form, thereby minimising the peak amplitude deviations of the signal and hence, reducing the overall peak-to-average ratio of the transmitted signal. This is particularly applicable in the case where there is a large power differential between the two binary phase-shift keyed (BPSK) information signals 49 and 51 and the combination process produces an asymmetrical constellation having a larger peak-to-average ratio.

Referring now to FIG. 4, an uplink design of the receiving unit 71, in accordance with a preferred embodiment of the invention, is shown. A processing device 70, e.g. a microprocessor, comprises two RAKE receivers 72 and 84 provided for recovering CDMA transmitted signals, as known to those skilled in the art. The processing device 70 further comprises two baseband mixing units 74 and 88, two complex-to-real functions 76 and 90, two delay functions 78 and 92 and two inverting functions 80 and 94. The processing device 70 receives recovered in-phase 'I' and quadrature 'Q' baseband signals and phase-shifting coded signals generated by a rotational generation means. The rotational generation means is preferably a phase-shifting rotational operator 86. The processing device 70 provides the recovered PDCH and PCCH information signals.

In operation the first (PDCH) RAKE receiver 72, in the processing device 70, receives the recovered baseband in-phase 'I' signal 73 and quadrature 'Q' signal 75. A first binary de-spreading code 77 (PN1) is input to a baseband mixing unit 74 where it is multiplied by a phase-shifting code 81, e.g. "1+j0" or "0+j1", generated by the phase-shifting rotational operator 86. The (complex) phase-shifted first de-spreading code 83 is input to a complex-to-real function 76 to provide in-phase and quadrature phase-shifted first de-spreading codes. One of the phase-shifted first de-spreading codes is input to a delay function 78 and delayed by a half-chip period. The

delayed phase-shifted first de-spreading code is input into an inverting function 80 to form the correct code for de-spreading and input to the first (PDCH) RAKE receiver 72 together with the non-delayed and non-inverted phase-shifted first de-spreading code. The delay function is not required if pseudo-QPSK rather than pseudo-OQPSK signals are required.

The second (PCCH) RAKE receiver 84 also receives the recovered in-phase 'I' signal 73 and quadrature 'Q' signal 75. A second binary de-spreading code 79 (PN2) is input to a baseband mixing unit 88 where it is multiplied by the phase-shifting code 81, e.g. "1+j0" or "0+j1", generated by the phase-shifting rotational operator 86. The (complex) phase-shifted second de-spreading code 85 is input to a complex-to-real function 90 to provide in-phase and quadrature phase-shifted second de-spreading codes. One of the phase-shifted second de-spreading codes is input to a delay function 92 and delayed by a half-chip period. The delayed phase-shifted second de-spreading code is input into an inverting function 94 to form the correct code for de-spreading and input to the second (PCCH) RAKE receiver 84 together with the non-delayed and non-inverted phase-shifted second de-spreading code. The second (PCCH) RAKE receiver 84 recovers the PCCH information signal from the 'I' and 'Q' input signals and provides a reference signal, e.g. a synchronisation and channel estimate signal 82, to the first (PDCH) RAKE receiver to enable recovery of the PDCH information signal from the 'I' and 'Q' input signals.

In this manner a pseudo OQPSK code division multiplexed transmitted signal is received and two binary phase-shift keyed (BPSK) information signals recovered by applying independent binary de-spreading codes 77 and 79 (PN1 and PN2) to the received signal. The binary spreading codes 44 and 46, used in the transmitting unit 48, are the same as the binary de-spreading codes 77 and 79, used in the receiving unit 71. It is within the contemplation of the invention that the binary spreading and binary de-spreading first and/or second signals may be combined in the phase-shifting signal generation, e.g. the rotational generation means may comprise the binary spreading and binary de-spreading signal generation means. The baseband mixing units 54, 56, 60, 74 and 88 are viewed as multiplying elements or rotational operational elements.

If the rotational operation, at the transmitting unit 48 , is performed in ninety degree steps the constellation of the quadrature imbalanced multiplexed signal 65 becomes symmetrical, even with signals having a large power differential. A ninety degree rotation is desirable as half of the elements in the phase-shifting code, if the phase-shifting code is

deterministic and alternates between "1+j0" and "0+j1", are zero, thereby simplifying the complexity of the design of the receiving unit 71. Using such regular deterministic phase-shifting codes 69 and 81 offers a lower peak-to-average ratio of the transmitted signal when compared to a pseudo-random phase-shifting code approach. For some power ratios, a further improvement can be made if forty-five degree phase-shifts are made, but as the phase-shifting codes 69 and 81 no longer have half of their elements equal to zero, the complexity of the design is increased.

Referring now to FIG. 5, a flowchart of the processing of uplink control and data information, at the transmitting unit, in accordance with the preferred embodiment of the invention, is shown. A call is initiated, in step 100, and the data, to be transmitted, and control channel information for the new frame is received, as shown in step 102. The data and control channel information are converted to signals of appropriate power and bit rate for transmission, as in step 104. Binary phase-shift keyed (BPSK) codes for the control channel and data channel are formed, as in step 108, and binary spreading codes are applied to the control and data channels, as shown in step 110. Two phase-shifting rotational operator signals are generated, in a quadrature form of "1+j0" and "0+j1", as in step 112, and are alternately applied to the binary-spread BPSK signals, as shown in step 114. The resultant 'I' and 'Q' signals are applied to band-limited baseband filters, as in step 116, and the signals up-converted and amplified to provide a signal for transmission, as shown in step 118. If there are more frames to process, as shown in step 120 the signal processing operation continues with the next frame of data and control channel information, as in step 102. If there are no more frames to process in step 120 the call is completed, as shown in step 122.

FIG. 6 is a flowchart of the processing of uplink control and data information, at the receiving unit, in accordance with the preferred embodiment of the invention. A call is initiated and the received signal synchronised, as shown in step 130. The received signal, corresponding to a new frame, is stored, as in step 132. The reference phase-shifting code, data channel code and control channel code are generated, as shown in step 134. The control channel reference signal (channel estimate) is formed and the real control channel binary spreading code is multiplied to the complex phase-shifting code, as in step 136. The control channel reference signal is applied to a control channel (PCCH) RAKE receiver and decoder, as shown in step 138, and the control channel frame and the channel estimate signal are generated, as in step 140. The channel estimate signal and information

rate is input to the data channel (PDCH) RAKE receiver, as shown in step 142. The data channel reference signal is formed and the real data channel binary spreading code is multiplied to the complex phase-shifting code, as shown in step 144. The data channel reference signal is applied to the data channel (PDCH) RAKE receiver and decoder, as in step 146, and the data channel frame is received and decoded, as shown in step 148. If there are more frames to process, as in step 150 the signal processing operation continues with the next frame of data and control channel information, as in step 132. If there are no more frames to process in step 150 the call is completed, as shown in step 152.

Four binary spreading operations are employed in the transmitter unit of the prior art. The transmitter design, in accordance with the preferred embodiment of the invention, uses two binary spreading operations and one complex spreading operation. As half of the elements of a complex code are zero, the complex spread is equivalent to two real spreading operations. Hence, the uplink transmitter unit will have the same complexity as for the transmitter unit of the RACE CODIT research project.

For the receiver unit of the prior art, four real de-spreading operations are necessary per branch of each Rake receiver. As half of the elements of the complex reference code are zero, the receiver design, in accordance with the preferred embodiment of the invention, uses only two binary de-spreading operations per branch of each Rake receiver. The formation of the reference signals is trivial since in effect the multiplication of the phase-shifting code with a binary code simply allocates the elements of the binary code to the real or imaginary components of the imaginary code. Hence advantageously, the uplink receiver will have less complexity than the receiving unit of the RACE CODIT research project.

Thus a method of processing and combining two BPSK signals to minimise the combined peak to average ratio is provided

Claims

1. A method for processing a first and second binary phase-shift keyed signal in a communications system having a transmitting unit and a receiving unit comprising the steps of:
at the transmitting unit,
scaling the first and second binary phase-shift keyed signals according to desired power and/or bit rates of the first and second binary phase-shift keyed signal to provide a scaled first and second binary phase-shift keyed signal,
adding the scaled first binary phase-shift keyed signal with the scaled second binary phase-shift keyed signals in quadrature to form a quadrature imbalanced multiplexed signal,
multiplying the quadrature imbalanced multiplexed signal by a first phase-shifting signal to provide a first transmitted signal; and
at the receiving unit,
receiving the first transmitted signal,
multiplying the first transmitted signal by a second phase-shifting signal to recover the first and second binary phase-shift keyed signals.

2. The method of claim 1, wherein the step of scaling the first and second binary phase-shift keyed signals according to desired power and/or bit rates of the first and second binary phase-shift keyed signal includes multiplying the first and second scaled binary phase-shift keyed signal by a first and second spreading signal to provide a scaled spread binary phase-shift keyed signal, and wherein the step of multiplying the first transmitted signal by a second phase-shifting signal includes multiplying the second phase-shifting signal by a first and second de-spreading signal to recover the first and second binary phase-shift keyed signals.

3. The method of any of the preceding claims wherein the first and second phase-shifting signals are regular deterministic phase-shifting signals.

4. The method of any of the preceding claims wherein multiplication by the first phase-shifting signal provides in the transmitting unit,

a rotation operation of the quadrature imbalanced multiplexed signal such that the quadrature imbalanced multiplexed signal is an orthogonal combination of the first and second scaled binary phase-shift keyed signals, and

wherein multiplication by the second phase-shifting signal in the receiving unit provides,

a rotation operation of the first transmitted signal in an opposite direction to the rotation operation of the quadrature imbalanced multiplexed signal in the transmitter unit.

5. The method of claim 2 wherein the first and second spreading signals in the transmitting unit and the first and second de-spreading signals in the receiving unit are binary spreading coded and binary de-spreading coded signals respectively.

6. The method of any of the preceding claims wherein at the receiving unit the second shared regular deterministic phase-shifting signal is multiplied by the first and second spreading signals to provide at least one reference signal for synchronisation and de-spreading purposes for recovering the first and second binary phase-shift keyed signals.

7. The method of any of the preceding claims wherein the second binary phase-shift keyed signal contains information necessary for recovering the first binary phase-shift keyed signal.

8. The method of any of the preceding claims wherein the communications system employs a Code Division Multiple Access (CDMA) scheme.

9. The method of any of the preceding claims wherein the signal processing operation of the receiving unit is as substantially described with reference to FIG. 6.

10. The method of claims 1 through 4 and claims 7 through 8 wherein the signal processing operation of the transmitter unit is as substantially described with reference to FIG. 5.

12

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9508974.4
Relevant Technical Fields (i) UK Cl (Ed.N) H4P PAQ (ii) Int Cl (Ed.6) H04L 27/18, 27/20; H04B 7/216	Search Examiner MR J P COULES
	Date of completion of Search 19 JULY 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-10

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,E	GB 2283627 A	(HEWLETT-PACKARD) see Abstract particularly Amplitude controlling inputs 50 and 51	1
X	GB 2282289 A	(HEWLETT-PACKARD) see Figure 4	1

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

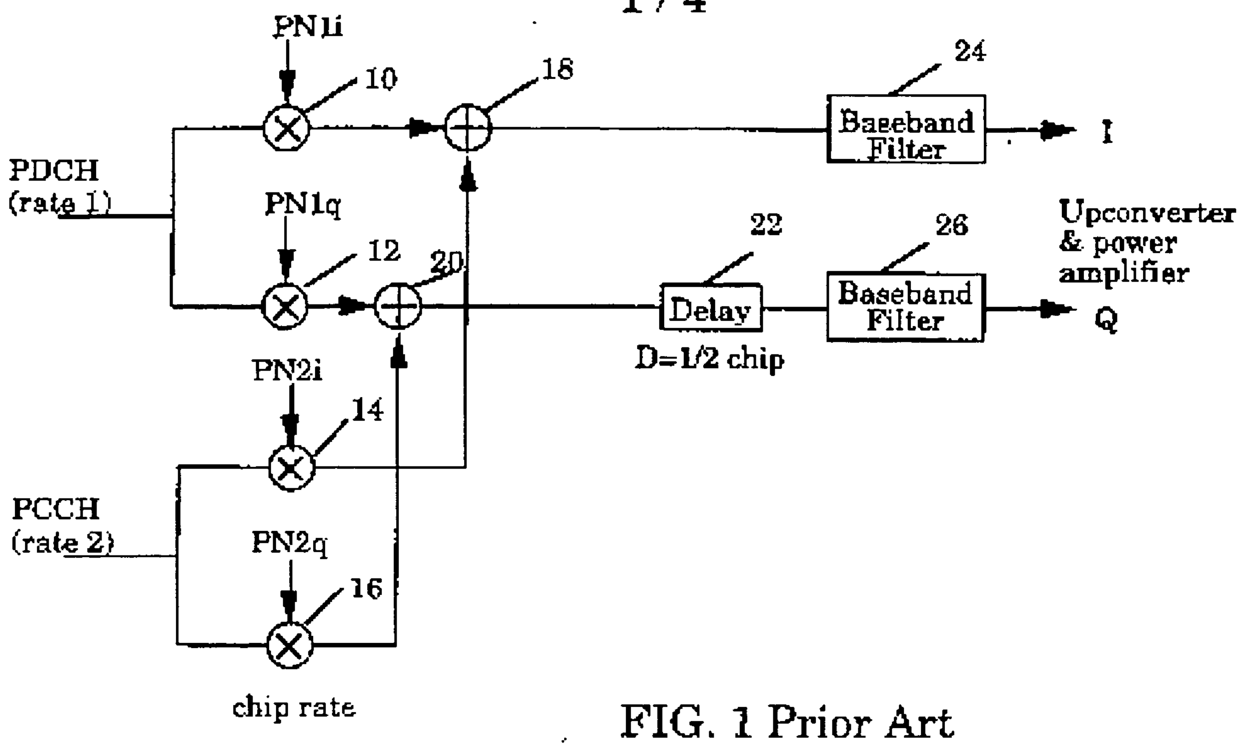


FIG. 1 Prior Art

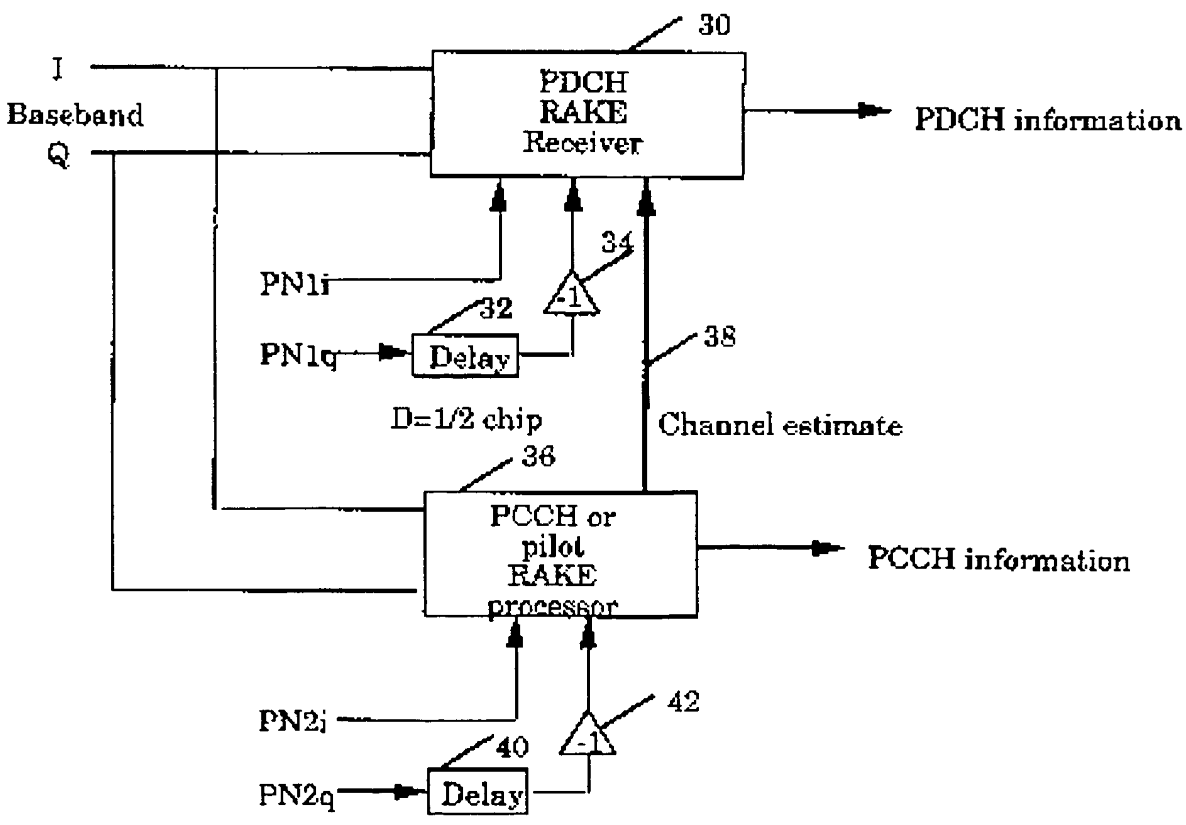
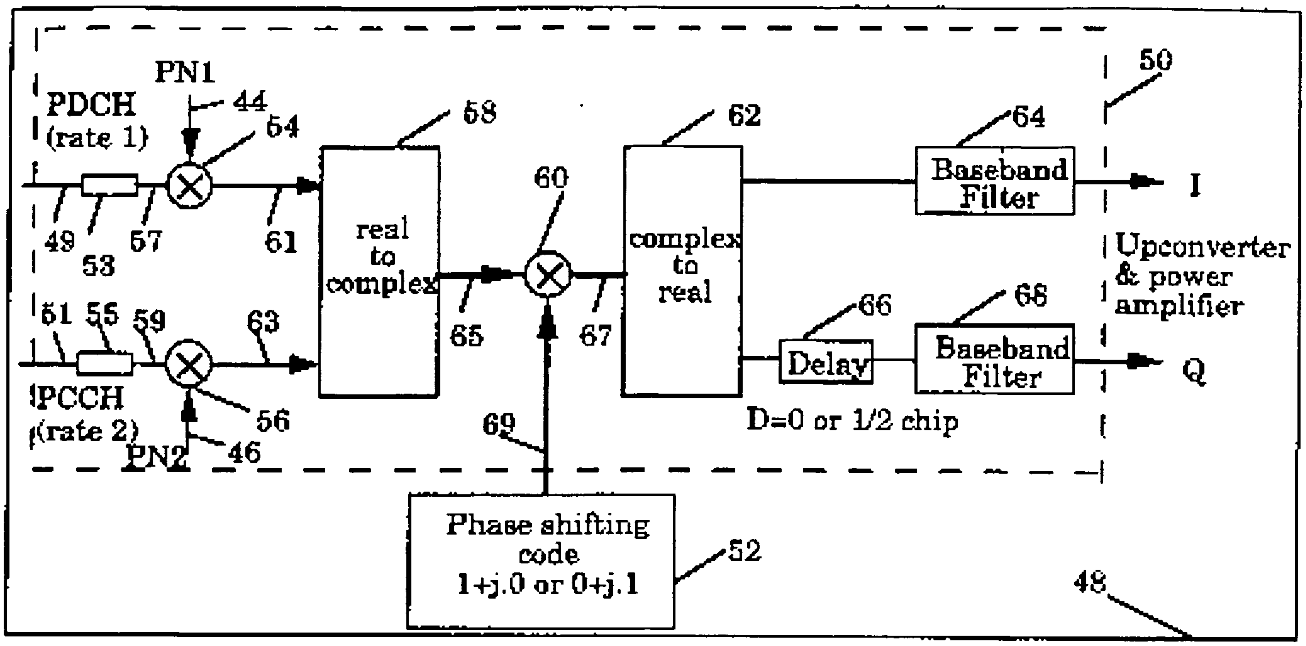
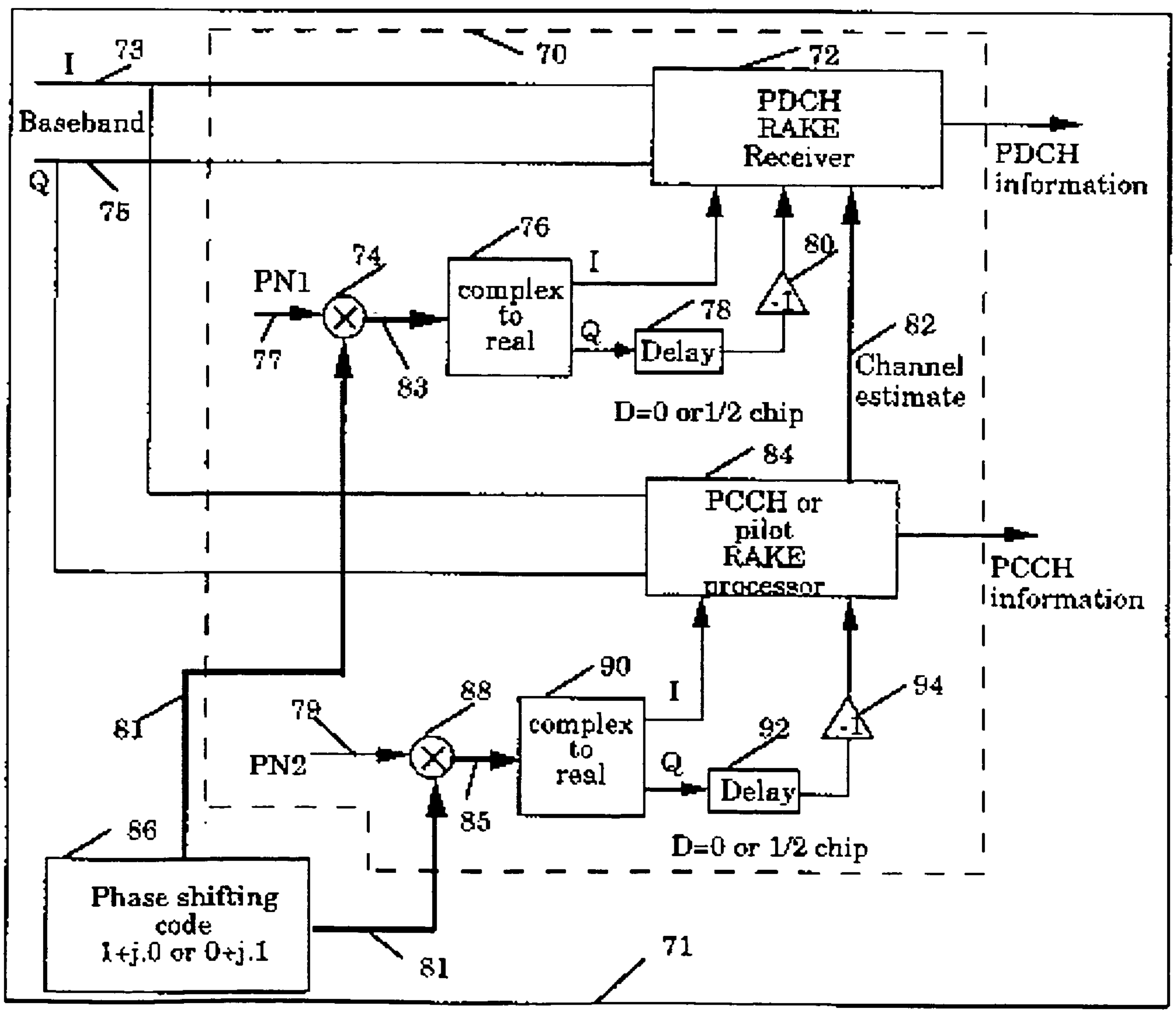


FIG. 2 Prior Art



PN1
PDCH
(rate 1)
44
54
58
62
64
50
49
53
57
61
real
to
complex
60
complex
to
real
Baseband
Filter
I
Upconverter
& power
amplifier
51
55
59
63
65
67
66
Delay
68
Baseband
Filter
Q
PCCH
(rate 2)
56
PN2
46
69
D=0 or 1/2 chip
Phase shifting
code
1+j.0 or 0+j.1
52
48

FIG. 3



I
73
70
72
Baseband
PDCH
RAKE
Receiver
PDCH
information
Q
75
76
PN1
74
complex
to
real
I
80
-1
78
Q
Delay
82
Channel
estimate
77
83
D=0 or1/2 chip
84
PCCH or
pilot
RAKE
processor
PCCH
information
90
88
94
79
I
92
-1
81
PN2
complex
to
real
Q
Delay
85
D=0 or 1/2 chip
86
Phase shifting
code
1+j.0 or 0+j.1
81
71

FIG. 4

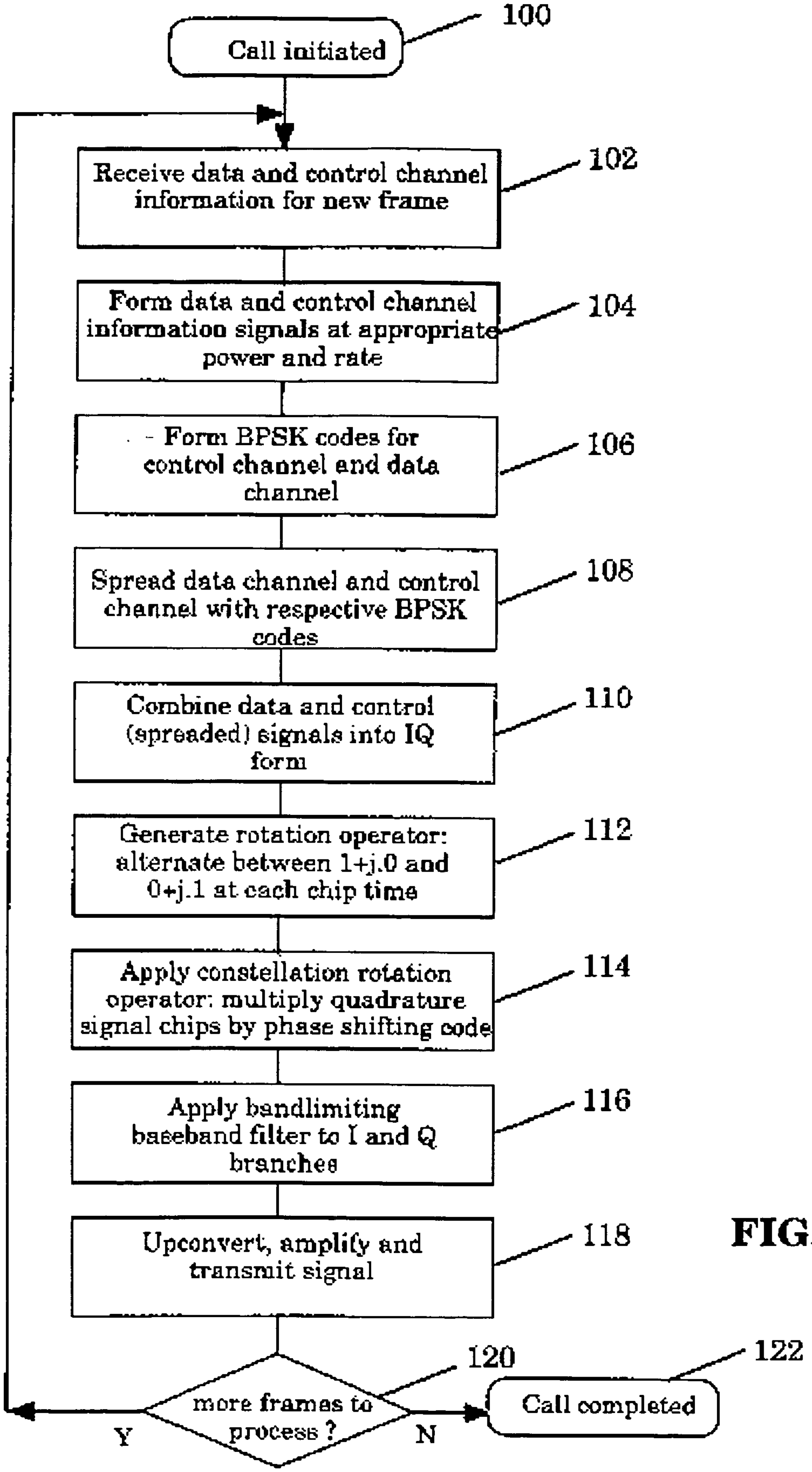
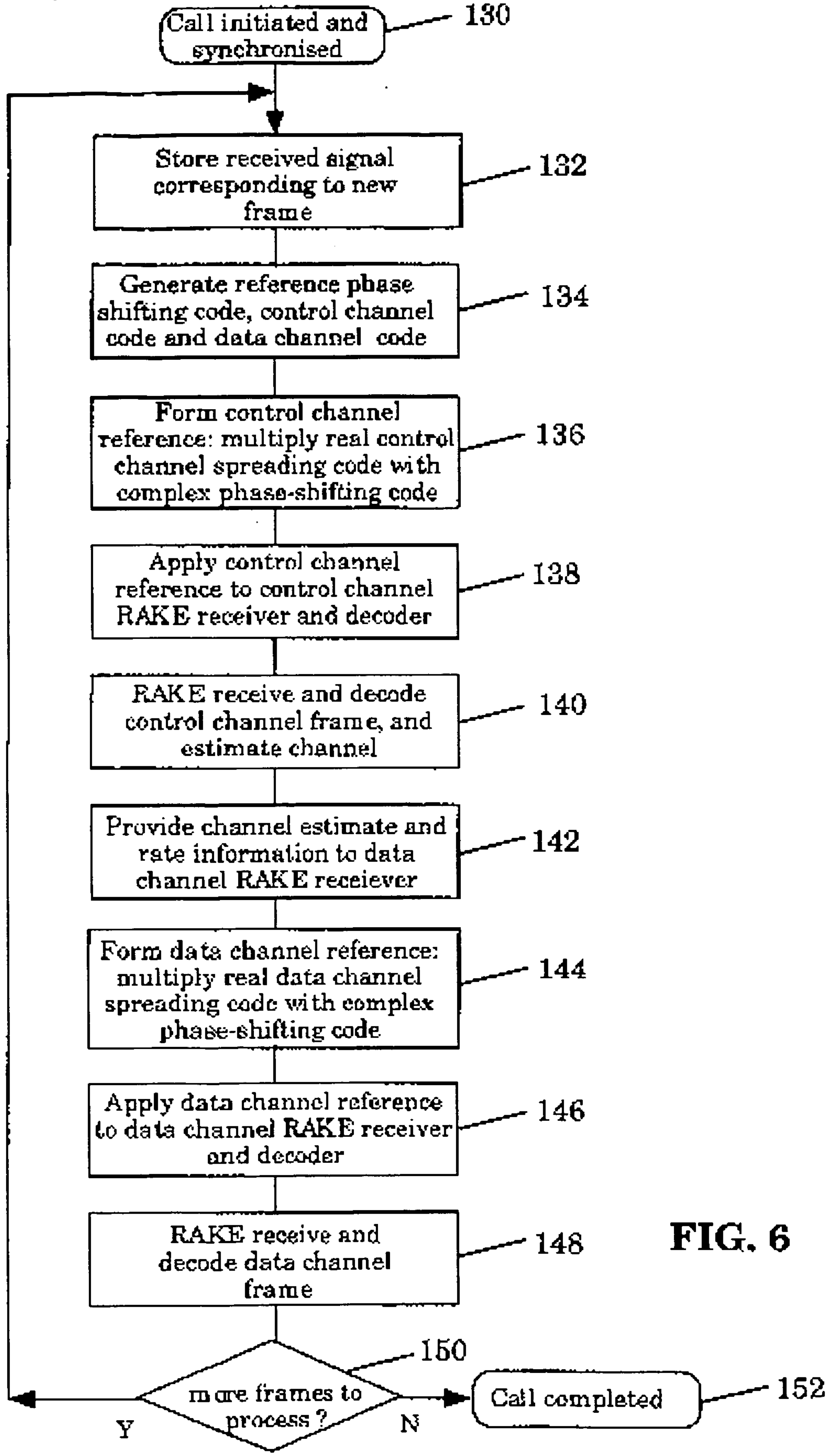

Call initiated
100
Receive data and control channel information for new frame
102
Form data and control channel information signals at appropriate power and rate
104
Form BPSK codes for control channel and data channel
106
Spread data channel and control channel with respective BPSK codes
108
Combine data and control (spreaded) signals into IQ form
110
Generate rotation operator: alternate between 1+j.0 and 0+j.1 at each chip time
112
Apply constellation rotation operator: multiply quadrature signal chips by phase shifting code
114
Apply bandlimiting baseband filter to I and Q branches
116
Upconvert, amplify and transmit signal
118
more frames to process ?
120
Y
N
Call completed
122

FIG. 5



Call initiated and synchronised
130
Store received signal corresponding to new frame
132
Generate reference phase shifting code, control channel code and data channel code
134
Form control channel reference: multiply real control channel spreading code with complex phase-shifting code
136
Apply control channel reference to control channel RAKE receiver and decoder
138
RAKE receive and decode control channel frame, and estimate channel
140
Provide channel estimate and rate information to data channel RAKE receiever
142
Form data channel reference: multiply real data channel spreading code with complex phase-shifting code
144
Apply data channel reference to data channel RAKE receiver and decoder
146
RAKE receive and decode data channel frame
148
150
more frames to process ?
Y
N
Call completed
152

FIG. 6